supplies the link in the chain which is in connection with the bodily nervous trouble at one end, and mental disorder at the other.

Heretofore our arguments were to a great extent purely metaphysical, and consequently we were little better off than our opponents, who advocated the possibility of possession good or bad, who believed in the miraculous and the nonsense so dear to the credulous mind in search of mystery. What an amount of bigotry, folly, and injury to weak minds is counteracted by the discoveries and investigations of MM. Charcot and Bourneville it is not difficult to imagine. The false lessons inculcated by designing persons who have used the disordered bodily and mental states of stigmatisation, ecstasy, and the legion of dramatic hystero-epileptoid symptoms for purposes of deception stand a good chance of being completely and universally neutralized. A. McL. H.

ART. XX.—*Cerebral Localization.*

Lectures on Localization in Diseases of the Brain. By Prof. J. M. CHARCOT. Edited by BOURNEVILLE. Translated by EDWARD P. FOWLER, M.D. 8vo. pp. 133. New York: Wm. Wood & Co., 1878.

The Localization of Cerebral Disease. By DAVID FERRIER, M.D., F.R.S., etc. 8vo. pp. 142. New York: G. P. Putnam's Sons, 1879.

Revue Générale des Sciences Médicales. Art. des Localisations Cérébrales Corticales. Par H. RENDU. pp. 298. 15 Janvier, 1879.

No subject during the last five years has attracted more intense and widespread attention from the medical world than that of cerebral localization. Rendu heads his admirable review with a list of more than a hundred works and articles published within three years. It is the great living question. Physiologists, pathologists, and physicians are deeply interested in the facts collected and the issues involved. We have a new phrenology, which is presented as a science and a system based, not upon crude speculation, but upon careful, laborious work, the value of which is not to be measured altogether by its direct fruits, whatever they may be. The names of Charcot and Ferrier, whose books are before us, are pre-eminent in the recent and important era of cerebral investigation.

The books of Charcot and Ferrier, although similar in title, are by no means alike in contents. Ferrier's volume, as the author states in his prefatory note, is the complement from a clinical and pathological standpoint of his former work on "The Functions of the Brain;" Charcot's contains matter essentially different from both of these. From the three works a complete idea of the subject of localization can be obtained.

Both books are issued in excellent style, and with illustrations so good that he may run that reads the lessons which they teach. Dr. Fowler's translation is indorsed by Charcot himself as a model both of scrupulous exactitude in rendition of the original meaning, and as a clear and unexceptionable style of English. No physician who aspires to keep pace with the advance of his profession should be without these works.

Charcot's lectures, here presented, are only the beginning of an extensive series; but his preliminary work is of the very best character. They constitute an elaborate anatomico-pathological study of the brain, an "exposition of the principles underlying the doctrine of cerebral localization." The encephalon is well discussed from a morphological point of view; a

brief parallel is drawn between spinal and cerebral lesions; the cerebral circulation is dealt with by the most lucid of methods; hemianæsthesia, amblyopia, and hemiopia are examined; and secondary degeneration receives a short but satisfactory setting forth.

In his opening lecture, after a few introductory remarks, he explains the shape and plan of the brain. Ganglia, lobes, convolutions, and connecting tracts are clearly described, and the importance of an appropriate nomenclature is strongly emphasized.

The peculiar structure of the gray substance of the brain, discussed in Lecture II. and Lecture III., speaks strongly for the probable truth of the doctrine of specific localizations. We cannot do better than present some of the most prominent facts in regard to the histology of the convolutions.

In the first place, the gray substance shows certain general characteristics, being made up essentially of the same elements; but important relative deviations may be presented according to the region observed. The ganglionic, or nerve-cells, are the special elements of the gray cortex. These are in every way comparable to the motor cells of the anterior cornua of the spinal cord. They are generally spoken of as the pyramidal cells. They are variable in dimensions, most of them being relatively very small. They are usually arranged into three classes, according to size. The largest are called giant pyramidal cells, and have been carefully studied by Betz and Mierzejewski; they are found in certain well-determined regions. Their diameters sometimes equal those of the cells of the anterior horns of the cord. The essential structure of all pyramidal cells is the same. They have numerous prolongations. Each contains a nucleus and brilliant nucleolus.

Besides the pyramidal cells, small globular cells, sometimes furnished with prolongations, also exist in the gray cortex. These are generally sparse, although sometimes they form a tolerably thick layer. Some regard them as incompletely developed nerve-elements; others compare them to the constituents of the granular layer of the retina.

Meynert ranks also among the nerve-elements of the cortex a kind of elongated, generally fusiform, ramified cell, which probably belongs to the system of fibres which connects the convolutions.

An amorphous cerebral tissue, the neuroglia, serves as a uniting substance. This resembles the type of ordinary conjunctive tissue, conjunctive fasciculi, and flat cells. These elements which compose the gray substance are arranged in certain methods. The most common type of arrangement is that which is met nearly everywhere in the anterior lobes, and which presents five successive layers. Charcot's description and exposition of these five-layer stratifications of cellular nerve-elements are highly suggestive as regards the probable functions of different districts of the cortex.

The regions remarkable for the existence of the giant pyramidal cells are precisely those in which, in the monkey, according to Ferrier, the psycho-motor centres of the limbs are located. These comprise the entire ascending frontal convolution, the superior extremity of the ascending parietal convolution, and the paracentral lobule.

Some points of great interest are cited by Charcot in connection with the histological study of what he terms "the department of the *giant pyramidal cells* or the *motor cells par excellence*." He gives, for instance, Lander's case of infantile spinal paralysis, in which autopsy revealed that the ascending convolutions were much shorter and less developed than normal, and that the paracentral lobule was entirely rudimentary. Landers believes that the development of the psycho-motor centres had been

arrested. The case of Luys is also quoted. In a subject in which amputation had been performed some years previous to autopsy, atrophy of the convolutions on the side opposite to the amputation was observed.

We have now in our possession a brain-specimen, awaiting microscopical examination, in which the ascending convolutions, paracentral lobule, and portions of the hemisphere posterior to the ascending parietal convolution, are notably atrophied and discoloured. The patient had had his leg, of the side opposite to that upon which these cerebral changes appear, amputated at least twenty years before his death.

An experimental observation of Soltmann is referred to by Charcot, to the effect that with newly born dogs the excitation of the psycho-motor regions produces no muscular movement in the corresponding limbs, whereas, some time after birth, towards the ninth or eleventh day, these points become excitable. Similar observations have been made since the publication of Charcot's lectures, and we incline to attribute to them great value. The fact that age, habits, and mode of life may greatly influence the size and development of encephalic centres has many important bearings. Recognizing its truth, we can account for some of the apparent anomalies and variations in size and position of centres in reported cases. The remarks with which Charcot terminates his consideration of this part of his subject are so full of suggestive interest that we cannot forbear quoting them :—

"The regions of the large cells belong to the five-layer type, and these regions have no definite anatomical characteristics except the presence of giant-cells. Now these giant-cells, morphologically, do not differ essentially from the large pyramidal cells, which also, according to the researches of Koschewnikoff, possess, like them, the nerve-prolongations in addition to the protoplasmic prolongations attributed to motor-cells.

"It seems natural to inquire if these cells, and even those of the smaller species, which are their miniature representatives, would not be capable, under certain conditions—under the influence, for example, of abdominal functional excitement—of acquiring development, and in that way giving birth to supplementary motor centres destined to replace primitive centres that by some lesion may have been destroyed. Thus, for example, might be explained how voluntary movements can be restored in a part, notwithstanding the destruction of a motor centre—a phenomenon an example of which is furnished in the frequent recovery from aphasia, in despite of the persistence of the lesion of the third frontal convolution."

The study of the cerebral circulation in the second part of Lecture IV., and in Lectures V., VI., VII., VIII., and IX., constitutes the most valuable portion of a valuable book. The vascularization of the encephalon is a subject of deep scientific interest, and, at the same time, of the most direct practical importance. The medical man, imbued with the proper spirit, can scarcely be engaged in a work more profitable and fascinating than the investigation of the arterial distribution of the brain. Charcot borrows largely from the work of Duret, a privilege to which he is certainly entitled, as this work was executed in the laboratory of Salpêtrière. At the beginning of his lectures on the arterial circulation in the brain, he steps aside to champion, apparently with some feeling, the cause of Duret against "a German doctor, Heubner." Duret and Heubner, unacquainted with each other, pursued their researches simultaneously, and in the most essential points arrived at identical results. Let us now quote from our author :—

"In a recent work treating of syphilitic alterations in the cerebral arteries, Heubner professes to have been the initiator. That is a claim which cannot be

sustained. The first researches of Duret relative to the circulation in the bulb and the protuberance were communicated to the Société de Biologie in the session of December 7, 1872.

"By a remarkable coincidence, the same day, the 7th of December, the *résumé* of the researches of Heubner upon cerebral circulation was published at Berlin in the *Centralblatt*. One month after, in January, 1873, Duret published a note in the *Progrès Médical* concerning that part of his researches which treated also of the cerebral circulation. The investigations of Duret are not, then, two years later than those of Heubner, as the latter insinuates; they are exactly contemporaneous. Of this fact Heubner might easily have convinced himself, as he has become acquainted with the last Mémoire of Duret, published in the *Archives de Physiologie* (1874), where the history of the question is given in detail.

"I have thought it well to insist upon this chronology," says Charcot with genuine Gallic spirit, "in face of the annexation mania, in order to establish the large part which belongs to our countryman."

In the exposition of the cerebral circulation, the question of the amount of communication between the different vascular regions of the brain is vitally important. Do anastomoses take place between the middle cerebral and the posterior cerebral distribution, between the anterior cerebral and middle cerebral, between the anterior and posterior, etc.? If these territories communicate, in what manner? To use the language of Charcot, "Are these communications easy and constant, or, on the contrary, are they accidental, indirect, and often impracticable?" The bearing of this problem upon the prognosis of cerebral thrombosis and embolism will at once be recognized. It is a question of life or death as regards the areas supplied by occluded vessels.

According to Duret, the main vascular territories of the brain are, in great measure, independent and isolated; communications between them are difficult or impossible. Heubner, on the other hand, believes that these are very easy, that they are made by the mediation of vessels not less than a millimetre in diameter. According to Duret, what anastomotic circulation is present takes place chiefly or exclusively through the capillaries. Charcot coincides with the conclusions of Duret, believing that they are more in conformity with pathological facts than those of Heubner. Cohnheim also agrees with Duret. He holds that the arteries of the encephalon, if not *final* or *terminal*, very nearly approach that type. By *terminal* or *final* arteries are meant those arteries or arterioles which, between their origin and their capillaries, neither furnish nor receive any anastomosing branch. The ramifications in the pia mater, the nutrient arteries of the cortex, and the vessels of the central ganglia, are believed to belong to this class.

Our own clinico-pathological observations are in the main strongly corroborative of the views of Duret, Cohnheim, and Charcot, however pleasant it might be to coincide with Heubner, whose opinions would enable us to give more roseate prognoses and to infuse more hope into our therapeutics. In exceptional cases, however, more or less easy communication takes place between arterial provinces usually isolated, which accounts for the pathological cases cited by Heubner, in which obliteration of one of the vessels of the cortical system or of its branches has, during life, given no evident symptom, and in which such obliteration causes no softening. At a recent autopsy, we saw a striking case of this kind. The artery of the ascending parietal convolution was completely obliterated in its middle third, and yet no softening of the convolutions beyond could be discovered on the closest examination. The patient had been a right hemi-

plegic, this condition being probably accounted for by an old cyst in, and extensive softening of, the left corpus striatum. In such a case, either collateral circulation must have been somewhere established, or the occlusion of the vessel, although probably for a long time partial, was not complete until just before death, and hence sufficient time had not elapsed for discoverable softening to occur. This latter mode of explanation of some of the apparently exceptional cases seems to us not at all unreasonable. The condition of the blood, and the rate of its flow, about the time of dissolution, might favour those final deposits on the diseased inner walls of vessels which would cause their complete closure.

The fact to which Duret has directed attention, of the frequent variations and anomalies of the circle of Willis and the communicants, is of practical value, and is one which we have often observed. If we do not bear it in mind, we may be led to false conclusions in cases of softening, hemorrhage, etc., in regard to the manner and method of communication between the different vascular territories of the brain. In searching for the arterial cause of necrosis, it must always be remembered that the communicants, as Duret informs us, are often filiform and entirely insufficient to re-establish circulation in case of obliteration. According to him, also, certain forms of anomalies explain cases of softening of an *entire* hemisphere, by a clot obliterating the internal carotid near its bifurcation. This softening of an *entire* hemisphere we must beg leave to doubt, although a large portion of a hemisphere may in this way be destroyed.

The very nature of the circulation in the brain, so well discussed in these lectures of Charcot, might, perhaps, be looked upon as an argument in favour of localization. The brain more than almost any other organ has specific regional supplies of blood; and, in accordance with the principle of the adaptation of parts to purposes, we might expect these districts which are furnished with special and peculiar vessels, to have functions specific and peculiar.

Intra-encephalic hemorrhage claims from Charcot the attention which it deserves. We will glance at only a few of the points. He divides the external striated arteries into an anterior and a posterior group. One of the anterior arteries is especially important, because of its size and its predominant rôle in intra-encephalic hemorrhage, and could, he says, be appropriately called the *artery of cerebral hemorrhage*. The method of studying this and all other vessels is minutely given. His observations on regional diagnosis, with reference to vascular supply, intra-encephalic hemorrhage, and occlusion of vessels, throw a flood of light upon a subject which is shadowy to most professional minds.

In the tenth lecture a fine comparison is drawn between hysterical hemianæsthesia and amblyopia which are due to cerebral lesion. His standpoint, which differs from that of many other observers, is laid down in the proposition that *cerebral lesions of the hemispheres which produce hemianæsthesia produce also crossed amblyopia, and not lateral hemiopia.* Charcot's hypothesis of double decussation of the optic fibres, now generally known, is here presented. A curious historical fact is mentioned in this chapter. It is, that the hypothesis of the semi-decussation of the optic nerves, usually attributed to Wollaston, is really due to Newton, who expressed it in 1704, in his *Treatise upon Optics*, and which Vater, in 1723, employed to explain three cases of hemiopia which had fallen under his observation.

Charcot's remarks on the analogies and differences between lateral sclerosis from cerebral cause and primitive fasciculated sclerosis of the

lateral fasciculi of the cord, are as suggestive as they are interesting. Most of the points indicated are now well known to the profession; but an important matter, often overlooked, is the fact that the consecutive sclerosis resulting from cerebral lesion acquires, after a given time, a sort of independent or automatic existence.

We lay down this well-translated volume, impressed anew with the genius of Charcot.

The work of Ferrier, which is made up of the Gulstonian lectures of the Royal College of Physicians for 1878, revised and supplemented by numerous additional facts and illustrations, contains some of the matter to be found in *Functions of the Brain;* but this is not to be deprecated, as it has been re-presented not for "padding," but for clearness and fulness of exposition. In Lecture I., after an argumentative and historical statement of the question of localization, lesions of the frontal lobes receive brief attention; in Lecture II. and the first part of Lecture III. lesions destructive and irritative of the motor zone are ably and fully set forth; and in the remainder of Lecture III. the areas for common sensation and the special senses are discussed.

Ferrier's exact position is not always understood, particularly by those by whom he is criticized. In regard to motor phenomena, he believes that the cerebral convolutions surrounding the fissure of Rolando contains psycho-motor centres, or centres for movements which involve conscious discrimination, which are volitional in the strict sense of the term. They are not purely "motor" centres, that is, centres for all movements of all kinds. "Those which are variously described as automatic, instinctive, or responsive, including all the motor adjustments concerned in equilibration, locomotor co-ordination, and instinctive emotional expression, are more or less completely and independently organized in the centres situated below the cortex."

He holds to the probable existence in the præ-frontal lobes of psychical centres. He advocates sensory localization, locating the sensory centres in the parieto-temporal region, situated between the motor-area and the occipital lobes, and including the supra-marginal lobule and angular gyrus or inferior parietal lobe, the convolutions of the temporo-sphenoidal lobe on its external and interior aspect, viz., the superior, middle, and inferior temporo-sphenoidal convolutions, the occipital temporal convolutions (lingual lobule, fusiform lobule), the uncinate gyrus, and hippocampus major or cornu Ammonis. In regard to the occipital lobes, his hypothesis is that they are specially related to the visceral or organic sensibilities.

His views also in regard to the functions of the great basal ganglia—the corpora striata and optic thalmi—can be briefly stated. From the cortical centres fibres pass down to the cerebral peduncles; broadly speaking, these ganglia are so placed in connection with these conducting bundles as to have the position, anatomically and physiologically, of bodies intermediate between the centres of the cortex and the parts below the hemispheres. Volitional movements originate in the gray superficial layers of the brain; these movements are more or less distinct and dissociated according to the centres in action. They may become automatic or organized.

"Movements," says Ferrier, "at first requiring true volitional effort—by which is meant action conditioned by consciously discriminated impressions present or revived—tend to become automatic by repetition, and the less varied and complex the movements, the more speedily does this automatic organization become established. It is evident from the facts of experiment on dogs that the

corpora striata are the centres in which this organization occurs. They form, as it were, the centres of automatic or sub-voluntary integration of the various voluntary-motor centres differentiated in the hemispheres." (*Functions of the Brain*, p. 252.)

The basal ganglia do not initiate either motor or sensory impressions, but they serve to receive and organize, to co-ordinate and harmonize, impressions originating in the scattered centres of the cerebral periphery. They are largely concerned with actions which have become habitual and automatic.

By far the strongest part of Ferrier's work is that which is concerned with motor phenomena. This is, of course, the phase of the general subject of cerebral localization, which, for many reasons, has been best worked out. These phenomena are objective; paralysis and spasm can be seen as well as experienced; the motor convolutions are easily reached by the physiologist, and are often the victims of disease.

The weak part is that which treats of lesions of sensory regions. Illustrative cases are far less numerous and convincing than those which speak for the motor areas. Some of the reasons for this are plain. Sensory phenomena are subjective; they are less readily determined by the physiologist, and are more apt to be overlooked by the physician. We fully agree with Ferrier, who, in speaking of the want of attention to certain sensory manifestations, asserts that the "latency has been in observation rather than in symptoms." Again and again, both in ward and in out-door hospital service, we have seen most important sensory affections passed by, sometimes temporarily, sometimes altogether. The average clinical investigator does not always possess the time, tact, and patience required for such work.

The ground taken in regard to the antero-frontal lobes, of the existence in them of psychical and inhibitory centres, is well sustained by cases and arguments, old and new. In the *Medical Times* for January 18, 1879, we published a case of frontal tumour, which, we think, favours the views of Ferrier, although it has been urged against it that, being a case of tumour, deductions in reference to localizations are not trustworthy. We believe, however, that careful analytical study will sometimes enable us to separate the general from the special phenomena of tumour cases.

The review of Rendu—himself a contributor to the facts as well as to the literature of cerebral localization—is a comprehensive and logical presentation of the subject. His standpoint can be judged from the following statement of this object:—

"We shall try, in this review, to show that the different suppositions by which it is sought to replace the theory of Ferrier, are much less plausible than his view, and that they do not rest on anything more certain. We see that the light is still far from being perfect regarding the intimate mechanism of the cerebral functions, and the calling into play of encephalic manifestations; nevertheless, the theory of cortical centres is the most acceptable; assuredly, it is that which is least in disaccord with clinical phenomena."

He discusses the subject in its physiological, pathological, and clinical aspect. Under the head of Physiology, he gives at length the views of Ferrier, and also those of his opponents—Brown-Séquard, Lussana and Lemoigne, Vulpian, Dupuy, and others.

First in importance are the very positive opinions of Brown-Séquard, according to whom the brain is composed of innumerable reflex centres, which are put into action by a multitude of different influences, intrinsic and extrinsic. His chief conclusions, now so well known, are that a lesion

limited to one-half of the brain, can produce symptoms on either side of the body; that a small lesion, whatever its seat, can produce the most extensive and violent symptoms; that a lesion on both sides of the median line of the brain can produce symptoms only on one side of the body; that sudden symptoms can proceed from a slowly progressive lesion, and *vice versa;* that the most diverse symptoms can proceed from an invariable lesion, and, reciprocally, lesions of diverse seat can give rise to the same symptoms; that permanent lesions can produce periodical or transient symptoms; that some cerebral symptoms have their origin in an irritation of the viscera or peripheral nerves; and that, finally, enormous lesions can exist in all parts of the brain without determining any symptoms.

These contradictory facts, according to Brown-Séquard, show that nerve cells possessed of definite functions, instead of being united in a certain cerebral territory, are dispersed throughout the encephalic mass, and are joined in some way one to the other, so as to form a functional solidarity. Each cerebral hemisphere, he believes, is a complete brain, sufficient of itself for the control of both sides of the body, but most individuals do not develop equally their two brains. The clinical conclusion to be drawn from such a view is that all symptomatic manifestations of cerebral origin arise exclusively from an irritation which acts, either by arresting the activity of the encephalon, or by exaggerating it. To the first category of symptoms belong, for instance, paralysis, aphasia, anæsthesia, amaurosis, etc.; to the second, delirium, convulsions, contracture, tremor, etc.

Rendu remarks very forcibly that in order to deny the results obtained by Ferrier from physiological experiments, it is necessary that conditions shall be identical. Brown-Séquard's experiments were performed on dogs, rabbits, and cobayes, and every one admits that hemiplegia in these animals, after destruction of a hemisphere, is far from being regular. In regard to his pathological data, he shows that Brown-Séquard has accumulated systematically all the facts and supposed facts unfavourable to the idea of a localized affection. Many of these have little or no value. Only a few are well established and irreproachable. Rendu asks, with reason also: Can a hundred observations suffice to render valueless daily clinical experience, and the thousands of cases which come to the notice of all physicians engaged in hospital practice?

The researches of Pierret and Flechsig, dwelt upon by Ferrier, but, strange to say, not alluded to in Rendu's able review, undoubtedly afford to the advocates of localization one of the most satisfactory explanations of Brown-Séquard's much flaunted exceptional cases of direct paralysis, that is, of paralysis occurring on the same side of the body as the lesion in the cerebral hemisphere. Flechsig has shown by embryological research that the decussation of the anterior pyramids at the junction of the spinal cord and medulla oblongata, instead of being regular, is very variable. His investigations were made upon the spinal cords and brains of sixty fœtuses. According to him the pyramids are adjuncts to the fundamental spinal tracts, and are developed later, their development coinciding with that of the hemispheres. They are absent in cases of non-development of the hemisphere. They can be traced above to the cortical regions and below to the postero-lateral, and partly to the anterior columns of the cord. As a rule, the fibres which decussate descend in the postero-lateral columns, and those which pass down directly into the cord do so in the anterior columns. Usually, in Flechsig's research, the crossed bundles predominated over the direct. Variations were very numerous; occasionally the direct fasciculi exceeded the crossed. In one case all the pyramidal fibres

crossed the median line to the lateral columns, in another only ten per cent. crossed over, ninety per cent. descending directly in the anterior columns. Flechsig believes it possible for the decussation of the pyramids to entirely fail.

Pierret (*Bull Soc. de Biologie*, Jan. 8, 1876, *Le Progrès Méd.*, Jan. 22, 1876) describes the case of a child in which almost the whole of the pyramidal strands were contained in the anterior columns as far as the middle dorsal region. In this case, in consequence of the almost complete absence of decussation, M. Pierret remarked that, had paralysis occurred as the result of a cerebral hemorrhage it would have shown itself in the arm of the same side, while the opposite leg would have been but slightly affected.

How much more satisfactory are explanations based upon these anatomical facts than the inverted reasoning and special pleading of Brown-Séquard? These variously decussating pyramids being the paths for the transmission of voluntary impulses, paralysis on the same side of the body as a brain lesion is possible, and does not constitute an unanswerable argument against the first and oldest fact in cerebral localization, that of the cross action of the cerebrum. In a word, the classical idea of hemiplegia has not been successfully assailed.

MM. Lussana and Lemoine hold that the white substance possesses the properties attributed by the advocates of localization to the gray. They say first that the cerebral cortex does not contain motor centres, and that its lesions do not produce paralysis; and secondly, that the peduncular system contains the true centres of motor innervation; that a lesion of this system always causes paralysis; if, sometimes, paralysis follows from a surface lesion, this depends always on indirect compression or on counter-pressure on the peduncular system. They completely deny the psycho-motor centres of Ferrier. They base their views first on the fact that the cortex responds only to electrical and not to mechanical or chemical stimuli, the peduncular fasciculi responding to all. This argument, Rendu shows, really proves nothing against the existence of psycho-motor centres. It simply appears that the gray substance does not comport itself in the same fashion as the white under diverse excitations, but this is the only legitimate conclusion that can be drawn. A second reason for neglecting the centres of Ferrier is the transient and incomplete character of the paralysis or paresis following lesions of the cerebral cortex. This objection, however, says Rendu, is more specious than real, if we reflect on the modifications of structure which the brain undergoes in the various degrees of the vertebral scale; if we especially think of the antagonism which Ferrier has shown to exist between the centres of voluntary innervation and the automatic motor centres. By admitting with most physiologists that the cerebral peduncles are only conducting bundles, emanating from this double series of centres, it is clear that their section would be followed by complete paralysis; but we cannot conclude from this that the peduncles are true motor centres.

We might say just here, as probably the most appropriate place, that the objection to cerebral localization and its physiological proofs, which has been so often advanced, namely, that it is impossible to localize the action of electric currents is far from having the weight which many suppose it to possess. Ferrier states this point well—

"On the conduction theory it would be natural to expect that the nearer we go to the underlying ganglia and tracks, the more readily the effects should be called forth if it were a question of mere resistance of currents. But we find

that electrization of the island of Reil, which is nearest the basal ganglia, is absolutely negative; while electrization of the more distant postero-parietal lobule by the same stimulus produces an immediate and definite movement. Conduction would seem to be put out of court by such facts. And we find, as Carville and Duret have shown, that the intervention of a fluid cyst between the cortex and the basal ganglia is quite sufficient to interpose a fatal obstacle to the preparation of functional stimulation, though not of electrical currents, just as a ligature round a nerve will stop neurility but not electricity."

Vulpian has adopted an opinion intermediate between that of Ferrier and Brown-Séquard. Establishing himself on the inexcitability of the gray substance in general, he concludes that all parts of the encephalon possess the same physiological properties. He has, however, repeated the experiments of Hitzig and Ferrier, and has recognized the existence of regions excitable by electricity, and giving rise to determinate movements. It is, therefore, rational to admit that to these regions come fibres exclusively motor, in intimate relation, on the one hand with the cerebral cortex, and on the other with the corpus striatum. The integrity of the gray substance is necessary to that of the nervous elements of the white substance which joins it. Irritation of deep-lying parts excites the superficial convolutions.

Dupuy has sought to prove that the contractions obtained by stimulating certain convolutions are only reflex phenomena, that they are due to irritation of the nerves of the pia mater and of the vessels. He founds his opinion upon such experiments as the following: He exposed the left hemisphere of a dog at the level of the fissure of Rolando, and faradized the adjacent convolutions, producing manifest movements of the right side. This done, with a white-hot cautery, he touched the motor centres still covered by the pia mater, and then again applied electricity to the parts cauterized, obtaining the same movements. The animal presented no paralysis save a little ptosis. At the end of four weeks it was absolutely cured, without any affection of motility or sensibility. Dupuy now reopened the wound and established the presence of a dried eschar adhering to the meninges. Electrical excitation of the eschar and of the subjacent fibres now provoked no movement, while the current applied around the eschar caused muscular contractions. Dupuy's conclusion, according to Rendu, is by no means unassailable. In the first experiment, irritation of the cauterized region induced movements, because the subjacent fibres were sound; later, these being destroyed, all transmission of peripheral excitation to central parts disappeared. Thus interpreted, the experiment rather supports the theory of cortical motor centres, but with the restriction of Vulpian, a restriction which Rendu is inclined to accept.

The re-establishment of motor functions after the destruction of cortical centres is discussed by Rendu. He recalls the opinion of Broadbent, that in such cases the opposite hemisphere at once effects a work of compensation; but in opposition to this, he also refers to the remarkable experiment of Carville and Duret, who cured a temporary paralysis consequent upon an operation upon one cerebral hemisphere by extirpating the cortical centres of the other side. He believes Ferrier's explanation of these phenomena to be the most plausible. Supporting himself on his physiological views of the respective rôles played by the cortical centres and the basal ganglia, he holds that the latter, especially the corpora striata, are so organized as to act when the functions of the convolutions are in default; automatism taking the place, in such cases, of voluntary impulses. Thus can be explained the numerous differences which are seen in different

species of animals after ablation of the encephalic cortical centres. A monkey, after this operation, becomes and remains hemiplegic; a dog is only transiently paralyzed, a pigeon is not paralyzed at all—and so on for different animals, according to the degree of their volitional and automatic organizations.

A large number of facts, pathological and clinical, have been collected, and are presented by Ferrier and Rendu; a few are given in the lectures of Charcot. These are particularly full and convincing in regard to destructive lesions of the motor areas. Case after case is given to show that paralysis of the muscles of the face, arm, or leg, may be the result of circumscribed lesions of the motor zone. It will not be necessary, except in special instances, to recall these cases. They have been quoted everywhere in current medical literature. The facts in regard to brachial and facial monoplegia are overwhelming; and brachio-crural monoplegia is a condition well made out. It may be, in reference to crural monoplegia, that we are simply in need of more numerous and accurate observations. The long-established doctrine of aphasia is re-emphasized by Ferrier with striking illustrations. One point made by him is worthy of special notice:—

"To overturn," he says, "the localization of a speech centre, it is not enough to bring forward a case of lesion of the left speech-centre without aphasia. This is admitted by all, and it is a very significant fact, that in several at least of the cases of aphasia with disease of the right speech-centre, the patients have been left-handed. It is incumbent upon the opponents of the doctrine of localization to bring forward a case in which, with bilateral lesion of this centre, no aphasia occurred. But, I need scarcely say, no such evidence exists."

The atrophy which occurs in certain cerebral regions because of the prolonged functional inertia which results from amputation or other cause; the secondary degenerations which follow lesions of the motor zones; the negative, but not unimportant argument, of the existence of latent cortical zones—these facts present other lines of reasoning well worked out by Ferrier and Rendu, but to these we have already referred.

The facts in regard to irritative lesions of the motor area strengthens at every point the position of the localizationists. In this field the labors of Hughlings-Jackson are pre-eminent. A knowledge of "Jacksonian epilepsy" is one of the recent signal acquirements of neurology. The pathology and symptomatology of irritative motor lesions point unerringly to the existence of cortical centres. It should never be forgotten that to Hughlings-Jackson belongs the great credit of having first indicated the motor functions of certain cortical regions, having been led up to this by observation of the phenomena of unilateral cerebral convulsions.

We are somewhat surprised that our author and the reviewer have not made more use of the numerous investigations into the symptomatology and pathology of dementia paralytica—of the researches of Meynert, Hitzig, Huguenin, and others. These are in the main confirmatory of the doctrine of localization. Ferrier contents himself with a mere allusion to the observations of Dr. Crichton-Browne on General Paralysis of the Insane.

We may, perhaps, be permitted to refer, at this point, to some cases of our own. This will be the more allowable because the observations were published too late to receive the attention of Ferrier and Rendu. In these cases (*Philadelphia Medical Times*, March 1, 1879) the symptoms produced by cortical lesions were, in the main, in accordance with the views of Ferrier, Charcot, and their school. They seemed to indicate, however, that the centres for leg, arm, and face are not so strictly and absolutely isolated in every human being as physiological experiment might lead us

to suppose. In one case, for instance, aphasia, partial right facial paralysis, marked paralysis of the right upper extremity, and paresis of the right lower extremity, were the results of softening confined to a small portion of the hinder part of the third frontal convolution, the lower end of the ascending frontal, the island of Reil, and a narrow segment of the adjoining temporal convolution. The major portion, but not all, of the region usually assigned to arm and hand movements, and the entire leg-centres, as usually given, escaped. In the second case paresis of the left face, arm, and leg, with left local spasmodic seizures, accompanied a lesion which distinctly involved portions of leg, arm, and face centres, and, therefore, it might be looked upon as strictly corroborative of the asserted facts in regard to localization. The third case was one of right hemiplegia with aphasia, partial hemianæsthesia, and unilateral convulsions, the lesion being softening of small outer rim of the island of Reil, a posterior segment of the third frontal convolution, the lower thirds of the ascending frontal and ascending parietal convolutions, the upper border of the first temporal convolution, the Sylvian border of the lower parietal, and the posterior portion of the upper parietal convolution. Except that the usually given leg-centres, high up in the ascending convolutions, were not involved, this case was one strongly confirmatory of Ferrier's views in regard to localization.

It might be here remarked that, on the whole, as Ferrier has noted, the centres for the movements of the leg have not been as clearly located and differentiated as those for the arm and face. The fact that in cases of paresis or paralysis of the arm or leg of cortical origin the lesion found does not occupy the *entire* area for the movements of these members does not necessarily militate against the view that these are the true centres for the limbs. In many instances the effects of a lesion doubtless extend beyond its strict limits. We have also thought that a sort of physiological coalescing or interaction of centres might sometimes take place. The movement of the leg and arm of one side being so constantly associated the centres for one may, to a certain extent, become capable of governing both. This, at least, is a view worth considering. Another point to be borne in mind is that, while the arm often acts independently of the leg, the latter is far less independent of the former in its movements. We write, strike, lift, and perform numerous acts with the upper extremity alone; but in walking, running, etc., the arms, as well as the legs, have parts of their own to perform. This may help to account for the fact that brachial and brachio-crural monoplegia are of much more frequent occurrence than pure crural monoplegia.

Our cases of lesion of the frontal lobes, of the basal ganglia, and of other encephalic regions besides the motor zones, also, on the whole, tend to the support of the doctrine of cerebral localization. Some of these are given in the article just quoted from; others have been presented, in connection with specimens, to the Philadelphia Pathological Society during the last and the present year, and have also been published in the Proceedings of this Society in the *Medical Times;* still other cases of both cortical and other lesions remain as yet unpublished. In short, out of more than a score of cerebral autopsies, made upon cases studied during life, we have only had two that seemed decidedly to conflict with the localization theories. One of these was a case of tumour of the brain (*ibid.*, March 29, 1879), which was situated in front of the optic chiasm, and the symptoms were chiefly those of marked left hemiplegia. The other was a case observed within a week of the time of writing, and it will hereafter be published

in detail. Softening of the pons, occupying both sides of the median line, was found, the patient several weeks before death having become paralyzed on the right of the body, the paralysis spreading just before death to the other side. Both of these cases, however, *can* be explained in conformity with the principles of localization. Tumours, owing to the general irritation which they often exert, and to the pressure-effects which result from them, sometimes give rise to symptoms which are apparently, but not really, in opposition to the view of the specific localization of functions.

Notwithstanding the immense additions which have been made to our knowledge of the physiology and pathology of the brain, especially with reference to the localizations of functions and lesions, the diagnosis of cortical paralysis from paralysis due to destruction of the corpus striatum or internal capsule, is not always easily made during life. This is pointed out by Ferrier in regard to hemiplegia depending on general destruction of the motor area of the cortex, and hemiplegia due to destructive lesions of the corpus striatum, more particularly those involving the anterior two-thirds of the internal capsule.

"There is the same relative affection of the different movements; those being most paralyzed which are most volitional, at least after the first rude shock of the disease has subsided. The facial paralysis is seen especially in the lower facial regions or in those movements which are most independent, while the frontal and the orbicular muscles of the eye are but slightly affected. The movements of the leg are less paralyzed than those of the arm, and the proximal movements of the arm less than those of the hand. Sensation is not affected if the lesion be strictly limited to the cortex or to the anterior two-thirds of the capsule; and in neither case is the nutrition or the electric contractility of the paralyzed muscles directly impaired. The same tendency exists to the development, sooner or later, of descending sclerosis of the motor tracts of the crus, pons, medulla, and spinal cord, and the appearance of late rigidity or contracture of the paralyzed limbs."

While all this is true, in a general sense, as Ferrier states, yet we are convinced that a very careful study of the two classes of hemiplegics will reveal points of dissimilarity which will largely help to a regional differential diagnosis. Fortunately, too, as Ferrier states, hemiplegia, complete from the first, and permanent, is not the most common type of paralysis depending on lesion of the cortex or subjacent medullary fibres.

"More frequently paralysis of cortical origin is fractional or dissociated, or is a succession of dissociated paralyses or monoplegiæ. In cortical affections we frequently find a hemiplegia, at first complete, resolving itself into a monoplegia, or a monoplegia becoming a hemiplegia by progressive advance of the disease to other motor centres. This latter is a significant indication of cortical disease. Paralysis of voluntary motion of the arm or leg, of the arm and face, or this combined with aphasia, if the lesion be in the left hemisphere, or paralysis of the inferior facial region, of the arm alone, or of certain movements of the hand and arm, or of the leg alone, without affection of sensation, and without qualitative or quantitative changes in electrical contractility, or direct impairment of nutrition, may be looked upon as depending on lesions of the cortex or subjacent medullary fibres."

Other points in diagnosis given by Ferrier are, the association with monoplegia, of monospasm and early rigidity, and convulsions sometimes in the limbs not paralyzed; the frequent erratic and transitory character of cortical paralysis; the fact that consciousness is less frequently lost in cases of sudden cortical lesion than when similar disease occurs in the central ganglia; the fact, noticed by Callender and others, that cortical

lesions are more frequently accompanied by localized pain in the head, and that observed by Ferrier himself, that even when pain is not spontaneously complained of, it may be brought out by percussion over the seat of lesion.

Ferrier closes his remarks on the diagnosis of cortical paralysis by the following condensed statement:—

"While we cannot be quite certain of the position or extent of a cortical lesion causing a sudden and complete hemiplegia, we may take a monoplegia of the leg or of the arm and leg as an indication of lesion of the upper extremity of the ascending convolutions close to the longitudinal fissure; brachial monoplegia as a sign of lesion of the upper part of the ascending frontal convolution, or, if the paralysis affect the hand more particularly, of the ascending parietal convolution; brachio-facial monoplegia as indicating lesion of the mid-fronto-parietal region; while facial and lingual monoplegia, or this combined with aphasia, indicate lesion of the lower part of the ascending frontal convolution, where the third frontal unites with it."

In discussing the question of the exact topographical diagnosis in cases of cerebral lesion, we cannot afford to overlook thermometry, general and local, and in local thermometry, the results obtained by taking head temperatures, and the temperatures of various local areas scattered over the body. Ferrier summarizes a few points. Although there is some difference of opinion, it is generally stated that there is less difference in temperature between the two sides when the paralysis depends on cortical than on central disease, and subsides more rapidly. Eulenburg and Landois, and Hitzig, hold that vaso-motor paralysis occurs in dogs, in consequence of destruction of the cortical motor centres. Vulpian and Küssner contest these facts. Ferrier believes the discrepancies to be more apparent than real, and that the same law holds good in reference to vaso-motor paralysis, which is observable in reference to the degree of motor paralysis following cortical lesions in different animals, and in respect to different movements in the same animals.

Broca, in 1877, published some observations on the temperature of the surface of the head in health and in disease, the observation indicating the possibility of determining local intra-cranial temperatures by applying thermometers externally. Lombard and others have experimented in a similar way with the thermo-electric pile. In the *New York Medical Journal* for August, 1878, Dr. Landon Carter Gray, of Brooklyn, has an article on *Cerebral Thermometry*, read before the American Neurological Association, June 20, 1878. In this paper he gives the results of observations upon 102 males, taking the temperatures of various regions of the head, left and right, frontal, parietal, occipital, etc. Among other things he found the average temperature of the left side of the head to be nearly a degree higher than that of the right; and the average temperature of the frontal and parietal regions to be nearly two degrees higher than that of the occipital. He refers to a case of tumour of the brain, occurring in the practice of Dr. Frank W. Rockwell, of Brooklyn, in which the diagnosis of the locality of the intra-cranial morbid growth was made with a thermometer, and afterwards verified by a *post-mortem* examination. Rendu, referring to the researches of Gray, says, that he believes that they do not prove anything except the existence of certain peripheral vaso-motor centres; that they do not demonstrate that the temperature of the head, in the various zones examined, corresponds to that of the brain; that perhaps they are simply explained by the richness and the greater or less superficiality of the arterial supply to the different regions of the scalp.

We are strongly inclined, from some experience in cerebral thermometry, to think that the criticisms of Rendu are not tenable, and that therefore the observations of Broca and Gray are of value as directing us to new aids in making regional diagnoses. In a case of brain tumour reported to the Pathological Society of Philadelphia (*Philadelphia Medical Times*, Jan. 18, 1879), we give a series of observations made with surface thermometers upon the head, which seems to show that we can attribute a positive value to local cerebral thermometry. The temperature of the surface near the seat of the growth was higher than that of other regions. We also have made a series of observations on another case of cerebral tumour, and numerous investigations in local and general thermometry in cases of hemiplegia, monoplegia, etc., all of which tend to show the value of such observations for the purposes of localization.

The study of localization has more than one hopeful therapeutical aspect. The supplementing of action by different parts of the encephalon is one of the sanguine prospects. This supplementation, as has been pointed out by Charcot and others, may take place between motor centres and ganglia, between various ganglia, and even between various parts of the same ganglion.

Duret's magnificent studies upon cerebral traumatism constitute a portion of the practical outflow from this new epoch of brain investigation. His theory of cerebro-spinal shock is of itself a discovery of sufficient importance to justify all the labours of all the localizationists. This same author and worker in the field of localization has given us new points of value in the diagnosis of diseases of the cerebral membranes.

In a review of this kind, we would fall short of justice to our subject, if we failed to refer to the direct surgical applications of the principles of localization. Although the instances in which the surgeon has been aided by the facts of localization are few in number and often quoted, they are none the less important and suggestive. Broca succeeded in locating an abscess in the third frontal convolution. Trephining has been performed in one case by Proust and Terillon, and in another by Lucas Championnière, the places for operating having been selected from a study of the symptoms of cortical lesions presented by the patient. The possibility of operating successfully in cases of cerebral abscess the position of which might be determined by a study, in the light of localization, of the phenomena of spasm, paralysis, or sensory disorder exhibited, has been proved by several reported cases. Huguenin mentions a case of this kind. Dupuytren operated successfully on one case of abscess of the hemispheres, and other similar cases are to be found in surgical treatises and memoirs.

In conclusion, we would simply say, that we are bound by the weight of evidence from every hand to give our unqualified assent to the doctrine which is embraced in the terse proposition of Charcot:—

"The encephalon does not represent an homogeneous organ, a unit, but rather an association, or a confederation, composed of a certain number of diverse organs. To each of these organs belong distinct physiological properties, functions, and faculties. Now the physiological properties of each one of these parts being known, it becomes possible to deduce therefrom the conditions of a pathological state; this being of course but a greater or less modification of the normal state, and not the result of the intervention of new laws."

In our opinion, "la belle doctrine" of cerebral localization is founded upon facts and principles which have not been, and probably cannot be, successfully gainsaid. It has withstood sneers and scepticism, and each day grows in favour as it grows in strength. C. K. M.